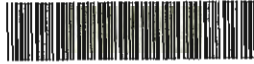


raf

TK2851 .S52 2012.



0000099254

Controlling DC motor variables (voltage, angular velocity and efficiency) to compare between nelder-mead method and powell's method of optimization / Sharul Izhar Aminuddin.

**CONTROLLING DC MOTOR VARIABLES
(VOLTAGE, ANGULAR VELOCITY AND
EFFICIENCY) TO COMPARE BETWEEN
NELDER-MEAD METHOD AND
POWELL'S METHOD OF OPTIMIZATION**

Sharul Izhar Bin Aminuddin

**Bachelor of Electrical Engineering
(Control, Instrumentation and Automation)
June 2012**

A-
99254
61

**CONTROLLING DC MOTOR VARIABLES (VOLTAGE, ANGULAR VELOCITY,
AND EFFICIENCY) TO COMPARE BETWEEN NELDER-MEAD METHOD AND
POWELL'S METHOD OF OPTIMIZATION**

SHARUL IZHAR BIN AMINUDDIN

**This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree Of
Bachelor Electrical Engineering (Control, Instrumentation And Automation)**

Faculty of Electrical Engineering

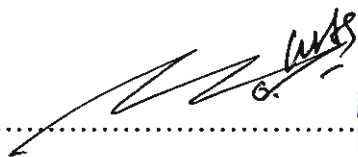
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2012

“I hereby declare that I have read through this report entitle “Controlling Dc Motor Variables (Voltage, Angular Velocity, And Efficiency) To Compare Between Nelder-Mead Method And Powell’s Method of Optimization” and found that is has comply that fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)”

Signature

:.....



MOSES ALFIAN SIMANJUNTAK
PENSYARAJI
Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

Supervisor's Name

: Mr. Moses Alfian Simanjuntak

Date

:.....

22/6/12

A-

7254
121

I declare that this report entitle "Controlling Dc Motor Variables (Voltage, Angular Velocity, And Efficiency) To Compare Between Nelder-Mead Method And Powell's Method of Optimization" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature

:.....

Name

: Sharul Izhar Bin Aminuddin

Date

: 22/6/2012

ACKNOWLEDGEMENT

In the name of The Almighty God who gave me the strength, health and patience to successfully implement and complete a final report. All the praise and selawat is upon to the prophet Muhammad S.A.W.

I would like to special thank my research supervisor, Mr. Moses Alfian Simanjuntak, because his support, encouragement and professional assistance.

I would also like to extend my gratitude, to my beloved parents for the moral, emotional and financial support. In addition, to my entire classmate at 4BEKC, Universiti Teknikal Malaysia Melaka who have been involved directly or indirectly in providing support and guidance during the making of this report.

I have gained a lot of help and support from friends and staff in the faculty of electrical engineering. I want to take this opportunity to say thank you to them for their advice and idea that help in my research.

Your sincere help will be remembered for life.

Thank you.

ABSTRACT

This project aims to optimize the efficiency as the dependent variable with voltage and speed as the independent variables of DC motor by using optimization process. DC motor is used because it has high energy and power to carry loads in addition to widespread use in the industries sector. Furthermore, this research will use two methods which are Nelder-Mead method and Powell's method to get the optimum efficiency. Finally, this method will be compared to obtain which one as the best estimation of the optimum efficiency. As conclusion the values of voltages in Powell's and Nelder Mead are different and the values of angular velocity (ω) also different. The minimum efficiency result of Nelder-Mead method is 0.01893 with the values of voltage 155V and angular velocity (ω) 193.747rd/s. Powell's method efficiency is 0.01895 with the values of voltage 155.011V and angular velocity (ω), 193.7677rd/s which makes it the Nelder-Mead method is better. However, the value of minimum $\frac{1}{\eta}$ for both methods is closely or approximately.

ABSTRAK

Projek ini bertujuan untuk mengoptimumkan kecekapan sebagai pembolehubah bersandar dengan voltan dan kelajuan sebagai pembolehubah bebas motor DC dengan menggunakan proses pengoptimuman. Motor DC digunakan kerana mempunyai tenaga yang tinggi dan kuasa untuk membawa beban disamping digunakan secara meluas dalam sektor industri. Selain itu, kajian ini akan menggunakan dua kaedah iaitu kaedah Nelder-Mead dan kaedah Powell untuk mendapatkan kecekapan optimum. Akhir sekali, kaedah ini akan dibandingkan untuk mendapatkan mana satu sebagai anggaran terbaik kecekapan optimum. Sebagai kesimpulan nilai voltan dalam Powell dan Nelder Mead adalah berbeza dan nilai-nilai halaju sudut (ω) juga berbeza. Hasil kecekapan minimum kaedah Nelder-Mead adalah 0,01893 dengan nilai-nilai halaju voltan 155V dan sudut (ω) 193.747rd/s. Kecekapan kaedah Powell 0,01895 dengan nilai-nilai halaju voltan 155.011V dan sudut (ω), 193.7677rd/s yang membuatkan kaedah-Mead Nelder adalah lebih baik. Walau bagaimanapun, nilai minimum $\frac{1}{\eta}$ untuk kedua-dua kaedah rapat atau lebih kurang.

CONTENTS

ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK.....	vi
CONTENTS	vii
LIST OF TABLE	ix
LIST OF FIGURES	x
LIST OF APPENDICES.....	xi
CHAPTER 1	1
1 INTRODUCTION.....	1
1.1 Project overview	1
1.2 Problem statement.....	3
1.3 Objective	3
1.4 Scope.....	3
CHAPTER 2	5
2 LITERATURE REVIEW	5
2.1 Introduction.....	5
2.2 Literature survey	5
2.3 DC Motor	6
2.4 Voltage and Speed (Angular velocity).....	7
2.5 Efficiency	7
2.6 Optimization.....	8
2.7 Nelder-Mead method	8
2.8 Powell's method.....	9
CHAPTER 3	10
3 METHODOLOGY	10
3.1 Introduction.....	10

3.2	Flow chart explanation.....	12
3.2.1	Concept and theory study	12
3.2.2	Problem in modeling.....	12
3.2.3	Modeling analysis	13
3.2.4	Computation	20
3.2.5	Analysis and result.....	20
CHAPTER 4		21
4	RESULT.....	21
4.1	Introduction.....	21
4.2	Experiment Procedures	21
4.3	Result	22
4.3.1	Result for Nelder-Mead Method.....	24
4.3.2	Result for Powell's Method	26
4.3.3	The result between Nelder-Mead method and Powell's method.....	31
CHAPTER 5		32
5	ANALYSIS AND DISCUSSION	32
5.1	Introduction	32
5.2	Analysis and Discussion	32
5.2.1	Nelder-Mead method	34
5.2.2	Powell's method	37
5.2.3	Conclusion of Nelder-Mead method and Powell method.....	40
CHAPTER 6		42
6	CONCLUSION AND RECOMMENDATION	42
6.1	Introduction.....	42
6.2	Conclusion	42
6.3	Recommendation	43
CHAPTER 7.....		44
7	PROJECT POTENTIAL	44
7.1	Introduction.....	44
7.2	Project potential	44
REFERENCES		46
APPENDICES		48

LIST OF TABLE

TABLE	TITLE	PAGE
4.1	Result for Nelder-Mead method	24
4.2	Iteration one for Powell's method	27
4.3	Iteration two for Powell's method	28
4.4	Iteration three for Powell's method	29
4.5	The result between Nelder-Mead method and Powell's method	31
5.1	Values for Best (G), Good (G) and Worst (W)	35
5.2	How a Reflection (R) process is located	36
5.3	The last iteration of Nelder-Mead method	37
5.4	The first iteration for minimum efficiency at P_1 and P_2	38
5.5	The second iteration for minimum efficiency at P_1	39
5.6	The third iteration for minimum efficiency at P_1 and P_2	39
5.7	The third iteration for minimum efficiency at P^*	40

LIST OF FIGURES

FIGURE	TITLE	PAGE
3.1	Flow chart of methodology	11
3.2	Flow chart for Nelder-Mead Method	16
3.3	Nelder-Mead step	17
3.4	Flow chart for Powell's Method	19
4.1	Configuration and connecting of equipment required for operating characteristics test	23
4.2	3D plot for Nelder-Mead method	25
4.3	3D plot for Powell's method	26
4.4	3D plot for Nelder-Mead method and Powell's method	31
5.1	Example of 3D optimization graph and contour	33

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Schematic Diagram for compound motor	48
B	Wiring Diagram for compound motor	49
C	The losses from motor	50
D	The result from experiment compound DC motor	51
E	3D plot coding for Nelder-Mead method	60
F	3D plot coding for Powell's method	61
G	3D plot coding for Nelder-Mead method and Powell's method	62
H	The actual equipment in experiment	63
I	The circuit for Compound DC motor experiment	65

CHAPTER 1

1 INTRODUCTION

1.1 Project overview

Optimization is an essential part of design activity in all major disciplines. Today, the globalization demands that additional dimensions such as location, language, and expertise must also merit consideration as new constraints in the development process. Improved production and design tools coupled with inexpensive computational resources have made optimization an important part of the process. Generally, the application of optimization implies the best result under the circumstances. This includes the particular set of constraints on the development resources, current knowledge, market conditions, and so on. The ability to make the best choice is a perpetual desire among us all [1] [3].

The techniques that are used in optimization are also used for obtaining solutions to nonlinear problems in many disciplines, so that the subject has an attraction to a wider audience from many fields. Optimization was described as the process of search for the solution that is more useful than several others. This means the outcome of applying optimization techniques to the problems, design and service must yield a number that will define the solution, in other words, a number or values that will characterize the particular design and service [3].

The optimization is math work with their product MATLAB and Simulink. The optimization toolbox, which implements most of the concepts developed in this

research. Knowledge of MATLAB is a skill that demands from those entering the workspace to work in analytical areas.

Nelder-Mead method and Powell's method in MATLAB are a famous methodology to use in optimization procedure. Nelder-Mead method still attract researcher from many areas even though as an old method [5]. For example Wang et al. applied this method for parameter estimation of chaotic system [6]. This shown method still efficient to choice by many practitioners in optimization. The method is to get the minimum value.

Powell's method is an extension of the basic pattern search method. It is the most widely used direct search method and can be proved to be a method of conjugate directions. A conjugate direction method will minimize a quadratic function in a finite number of steps. Since a general nonlinear function can be approximated reasonably well by quadratic function near its minimum, a conjugate directions method is expected to speed up the convergence of even general nonlinear objective functions. The definition, a method of generation to conjugate directions and the property of quadratic convergence are presented in this section [7].

MATLAB is introduced by Mathwork as the language for technical computing to design and define the minimum or maximum value. Borrowing from the description in an earlier brochure, valid even now, MATLAB integrates computation, visualization and programming in an easy to use environment where problems and solutions are expressed in familiar mathematical notation.

MATLAB is a standard tool for introductory and advanced to courses in mathematics, engineering and science in many universities around the world. In industry, it is a tool of choice for research, development and analysis. MATLAB basic array element is exploited to manipulated vectors and matrices that are natural to the subject. Its powerful visualization features are used for graphical optimization [3]. Method from MATLAB to optimization in my research is Nelder-Mead method and Powell's method.

The Nelder-Mead method and Powell's method is using to optimize the efficiency DC motor. The efficiency is the ratio between power out and power in.

Therefore, it is the purpose of this research to optimize the maximum efficiency of DC motor using MATLAB simulation.

1.2 Problem statement

In order for dc motor to function properly, it must be protected from physical damage during the starting period. Since the internal resistance of a normal dc motor is very low compared to its size, very high current flows. The output power, P_{out} of DC motor not exactly same with input power, P_{in} . It is because of that in this research want to know how to control voltage and angular velocity then the output power, P_{out} to be approximately to input power P_{in} .

1.3 Objective

The objectives of the research are:

- a) To obtain the maximum efficiency of compound DC motor.
- b) To compare the two methods between Nelder-Mead method and Powell's method.

1.4 Scope

The scope and limitation of this research is use compound DC motor in motor with the rated value of the motor is 220V, 1.1kW, 60nM and 0.24A. The brand of this compound DC motor is De Lorenzo motor. In this research will use the Machine Electrical Lab 1 (Universiti Teknikal Malaysia Melaka, UTeM) to do a the experiment. In the experiment it will obtain and collect the data before the data will be compute by

MATLAB. The result will be use MATLAB simulation to get the minimum surface for speed (angular velocity), ω and voltage.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Introduction

In this chapter, the variety of sources such as journals, article reviews and other research material used to get an idea of the scenes of the project, the concept and related information with it. The information will be become additional source for the project in becoming more successful. In addition, the chapter also shows projects that have been done by the previous person of which is correlated with the research. It is very important to enhance the understanding of this project as well as making this project successful.

2.2 Literature survey

Based on the previous research, optimization has become a necessary part of design activity to developed some product or system. Tajjudin. M, Ishak.N, Ismail.H, Rahiman M.H.F and Adnan.R applied the optimization process to optimize the PID controller using Nelder-Mead method. In this research, they want to improve the performance of electro-hydraulic position control. The first step they do is to do experiments to find the appropriate number of variables to make the system more stable. After researchers get the real data,they will be compute the data with using the Nelder- Mead methodology based the programing language in

MATLAB tool[5]. Besides that, this method also has been used by Chen W.C and Tzou.Y.Y in term to optimized the efficiency for controller dc motor but what the difference is this paper utilizes the current-control scheme to improve the current response and remove the current spike at the beginning and end during each commutation cycle is use the engineering term to solve the optimization process [13].

For this research, is purposed to controlling DC motor variables (voltage angular velocity and efficiency) to compare between Nelder-Mead method and Powell's method of optimization.

2.3 DC Motor

DC Motor converts electric energy into mechanical energy. A DC Motor uses direct current in other words, the direction of current flows in one direction. DC motor play an important role in the industry for speed and torque can be controlled easily. DC motor is more popular than AC motor because of its more flexible, such as the ability to produce a high starting torque and velocity control to be effective.

DC motors have three different ways with the armature and field to provide varying amounts of torque or different types of speed control. The armature and field windings are designed slightly differently for different types of DC motors. The three basic types of DC motors are the series motor, the shunt motor, and the compound motor. The series motor is designed to move large loads with high starting torque in applications such as a crane motor or lift hoist. The shunt motor is designed slightly differently, since it is made for applications such as pumping fluids, where constant-speed characteristics are important. The compound motor is designed with some of the series motor's characteristics and some of the shunt motor's characteristics (APPENDIX A & B). This allows the compound motor to be used in this research where high starting torque and controlled operating speed are required [8] [9] [12].

2.4 Voltage and Speed (Angular velocity)

Speed of a motor is proportional to the voltage. When the supply specified voltage to a motor, it rotates the output shaft at some speed. This rotational speed or angular velocity ω , is typically measured in radians/second {rad/s}, revolutions/second {rps}, or revolutions/minute {rpm}.

$$\omega = 2\pi Nr/60 \quad (2.1)$$

The relationship between voltage and angular velocity can influence the efficiency the DC motor [8], [9].

2.5 Efficiency

The efficiency is ratio between P_{out} and P_{in} and efficiency is a picture of how efficiently a motor in converting electrical energy into mechanical energy.

The formula of efficiency is

$$\eta = \frac{P_{out}}{P_{in}} \quad (2.2)$$

Where,

$$P_{out} = \frac{2\pi \cdot \omega \cdot \tau}{60}$$

$$P_{in} = V_1 \cdot (I_1 + I_2)$$

τ : torque

ω : Motor speed (angular velocity)

V_1 : input voltage of the DC motor

I_1 : Armature current of the DC motor

I_2 : shunt excitation current of the DC motor

In this research, the efficiency will be optimized by using Nelder-Mead method and Powell's method to get

$$\text{Min } \frac{1}{\eta} = \frac{P_{in}}{P_{out}} \quad (2.3)$$

2.6 Optimization

Optimization is in essence, a search for the best objective when operating within a set of constraints [3]. Optimization deal with finding the maxima and minima of a function that depends on one or more variables. The aim is to determine the values of the variables that yield maxima or minima for the function. These can then be substituted back into the function to compute its optimal values [1]. There are three major aspects of optimization which are identified as theory, algorithms and application [4]

2.7 Nelder-Mead method

The method is a pattern search that compares function values at the three vertices of a triangle. The worst vertex, where function is largest, is rejected and replaced with a new vertex. A new triangle is formed and the search is continued. The process generates a sequence of triangles (which might have different shapes), for which the function values at the vertices get smaller and smaller. The size of the triangles is reduced and the coordinates of the minimum point are found [2].

2.8 Powell's method

Let X_0 be an initial guess at the location of the minimum of the function. Assume that the partial derivatives of the function are not available. An intuitively appealing approach to approximating a minimum of the function is to generate the next approximation X_1 by proceeding successively to a minimum of function along each of the N standard base vectors. The process generates the sequence of points and the coordinates of the minimum point are found [2].

CHAPTER 3

3 METHODOLOGY

3.1 Introduction

This chapter will discuss about the methodology in this research. Methodology is a part that will explain about the research path. Careful planning and the steps that have been proposed and the information gathered are to produce the necessary steps to achieve the project objectives. This chapter describe about the methods and the procedures on how this project is done.

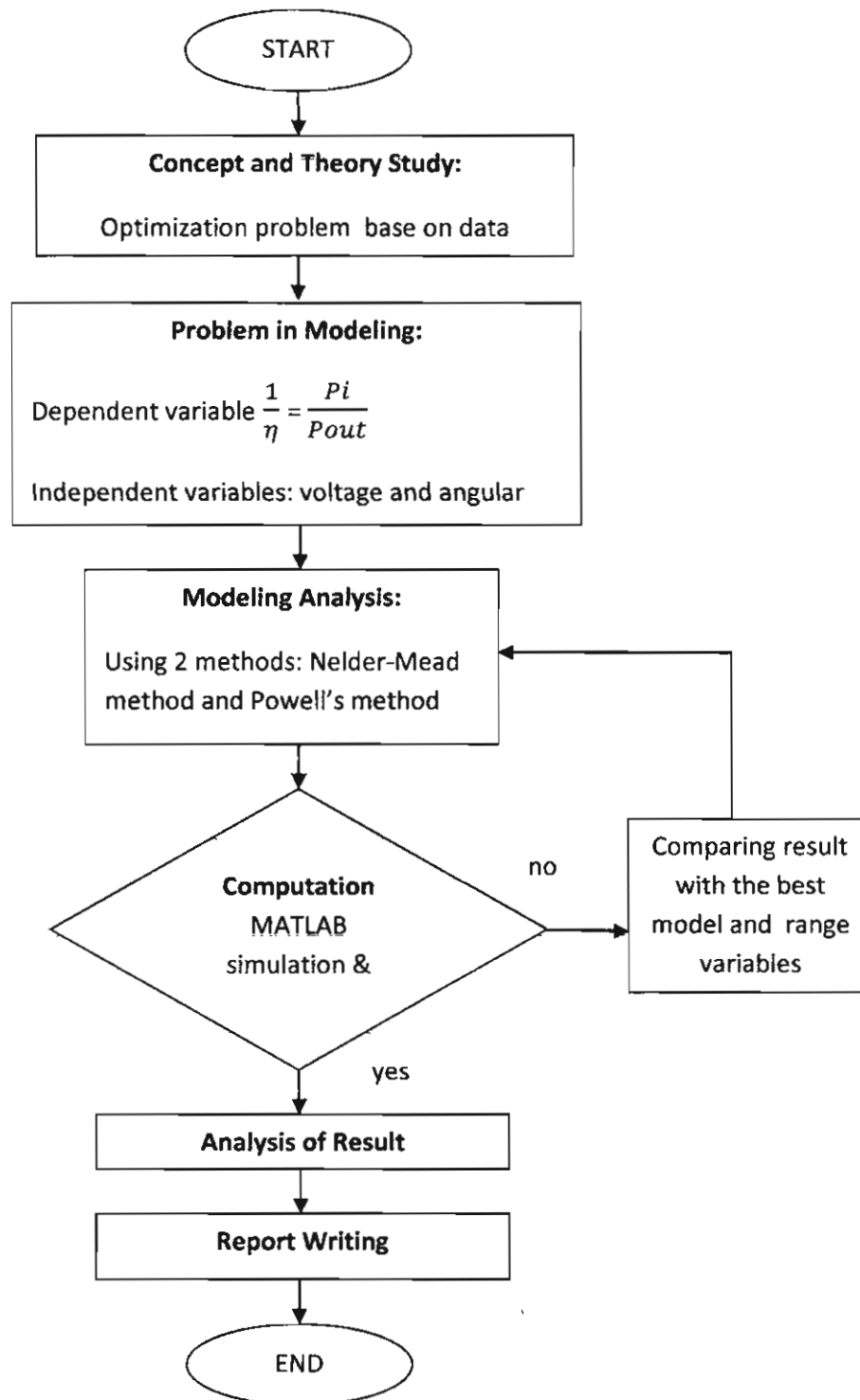


Figure 3.1: Flow chart of methodology

3.2 Flow chart explanation

The explanation of the flow chart.

3.2.1 Concept and theory study

This phase also called data-gathering stage, which is in this phase resource, will be identified to obtain data and information related for this project. Data and information will be collected from related sites and authorities, and the best ways of data gathering is from book and IEEE website. The data that it collected from compound DC motor connection will be applied in optimization.

3.2.2 Problem in modeling

Dependent variable is $\frac{1}{\eta} = \frac{P_{in}}{P_{out}}$

And independent variables are voltage and speed (angular velocity).

The name of experiment is “DC Motor Operating Characteristic (compound DC motor)”. The equipment that used are:

- Output turret (for electric measurements and machines).
- Compound excited DC motor.
- Electromagnetic brake + 2 measuring weight
- Voltmeter.
- Ammeter (2.5/5A)
- Ammeter (12/24A)
- Starting rheostat.
- Excitation rheostat.
- Tachometer.